



第六章 重大设备的失效分析

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目录



- 6.1 核电装置的失效分析
- 6.2 火电装置的失效分析
- 6.3 石化装置的失效分析
- 6.4 化工设备的失效分析
- 6.5 冶金设备的失效分析
- 6.6 汽车部件的失效分析
- 6.7 电子电路的失效分析
- 6.8 风电设备的失效分析
- 6.9 城市管网的失效分析



6.1 核电装置的失效分析

6.1.1 典型案例分析

- (1) 核电厂 RCW热交换器传热钛管的失效分析与治理方案
- (2) 核电厂凝汽器钛管异常减薄的失效分析与解决对策
- (3) 核电厂汽轮机EH系统油动机密封圈意外泄漏的失效分析
- (4) 核电厂乏燃料储存水闸门减速器异常断裂的失效分析
- (5) 核电厂消氢系统工艺管道泄漏的失效分析与解决方案
- (6) 核电厂汽轮机系统循环水泵地脚螺栓异常断裂的失效分析
- (7) 核电厂汽轮机系统凝升泵角接触滚子轴承的失效分析
- (8) 核电厂循环水泵闸阀驱动杆异常断裂的失效分析
- (9) 核电厂核岛硼酸再循环泵转动轴意外断裂的失效分析
- (10) 核电厂冷却循环水泵磨损的失效分析与对策
- (11) 核电厂核岛高分子材料电缆线辐照损伤的老化寿命评估

6.1 核电装置的失效分析

6.1.2 主要参考文献

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- (4) Fei-Jun Chen, Chen Yao, Zhen-Guo Yang*. Failure analysis on abnormal wall thinning of heat-transfer titanium tubes of condensers in nuclear power plant PartII: erosion and cavitation corrosion. *Engineering Failure Analysis*, 2014, 37: 42-52.

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- (8) Tong-Wei Ni, Qun Ding, Zhen-Guo Yang*. Failure analysis of abnormal fracture of boric acid pump shaft in 1000MW nuclear power plant. *Engineering Failure Analysis*, 2018, 92: 317-326.
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6.2 火电装备的失效分析

6.2.1 典型案例分析

- (1) 超超临界1000MW机组循环水泵异常断裂的失效分析和解决对策
- (2) T91钢异种钢焊接工艺评定及寿命评估分析
- (3) 超超临界机组用T/P92异种钢焊接的蠕变寿命评定
- (4) 锅炉二次过热器后屏炉管的腐蚀失效分析
- (5) 600MW电动机SKF滚动轴承的失效分析
- (6) EH系统油动机螺栓断裂的失效分析

6.2.2 主要参考文献

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6.2 火电装备的失效分析



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- (3) Zhi-Qiang Yu, Zhen-Guo Yang. Analysis of fatigue fracture on the outer ring of a cylindrical roller bearing in an air blower motor. Journal of Failure Analysis and Prevention, 2012, 12(4) : 427–437.**
- (4) Jian Cao, Yi Gong, Zhen-Guo Yang*. Microstructural analysis on creep properties of dissimilar materials joints between T92 martensitic and HR3C austenitic steels. Materials Science and Engineering A, 2011, 528: 6103-6111.**
- (5) Jian Cao, Yi Gong, Kai Zhu, Zhen-Guo Yang* et al. Microstructure and mechanical properties of dissimilar materials joints between T92 martensitic and S304H austenitic steels. Materials and Design, 2011, 32(5): 2763-2770.**

6.2 火电装备的失效分析



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- (9) Zheng-Fei Hu, Zhen-Guo Yang.* An investigation of the embrittlement in X20CrMoV12.1 power plant steel after long-term service exposure at elevated temperature. *Materials Science and Engineering A*, 2004, 383(2): 224-228.

6.3 石化装置的失效分析

6.3.1 典型案例分析

- (1) 年产109万吨聚乙烯装置急冷油/稀释蒸汽换热器管子的腐蚀失效分析
- (2) 高压聚乙烯装置循环气体冷却器爆裂的腐蚀失效分析
- (3) PTA聚酯装置干燥器的失效分析及其解决对策
- (4) 加氢精制PTA聚酯装置的失效分析及治理方案
- (5) 受火损伤后石化设备HDPE管道的试验分析与寿命评定

6.3 石化装置的失效分析

6.3. 2 主要参考文献

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6.3 石化装置的失效分析



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6.4 化工设备的失效分析

6.4.1 典型案例分析

- (1) 废热锅炉系统低温省煤器腐蚀泄漏的失效分析与治理方案
- (2) 氨气蒸发器热交换管异常减薄的失效分析
- (3) 高硫含量循环流化床锅炉设备的腐蚀失效分析
- (4) 腐蚀条件下设备的防腐蚀材料的制备与分析

6.4.2 主要参考文献

- (1) Qun Ding, Xiao-Feng Tang, Zhen-Guo Yang*. Failure analysis on abnormal corrosion of economizer tubes in a waste heat boiler. *Engineering Failure Analysis*, 2017, 73: 129-138.
- (2) Shi-Meng Hu, Sheng-Hui Wang, Zhen-Guo Yang*. Failure analysis on unexpected wall-thinning of heat exchange tubes in ammonia evaporators.

¹²Case Studies in Engineering Failure Analysis, 2015, 3: 52-61.

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6.5 冶金设备的失效分析



6.5.1 典型案例分析

- (1) 高炉炼焦气燃气轮机叶片的腐蚀断裂分析
- (2) 蠕变温度下耐热钢的碳化物析出表征及老化分析
- (3) 火电厂过热器和异种钢焊接的失效分析和性能评价

6.5.2 主要参考资料

- (1) Kai Zhu, Zhen-Guo Yang*. Effect of Mg Addition on the Ferrite grain boundaries microorientation in HAZ of low carbon steels. *Journal of Materials Science & Technology*, 2011, 27(3): 252-256.
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6.6 汽车部件的失效分析

6.6.1 典型案例分析

- (1) 轿车踏板用纤维增强复合材料部件的失效分析
- (2) 汽车密封件用纤维增强复合材料密封填片的力学性能分析

6.6.2 主要参考文献

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6.7 电子电路的失效分析

6.7.1 典型案例分析

- (1) 芯片引线框架高速电镀不锈钢钢带的失效分析
- (2) 手机用BGA焊点及盲孔开裂的失效分析

6.7.2 主要参考文献

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6.7 电子电路的失效分析

6.7.3 典型案例分析

- (1) 高密度PCB电镀铜互连盲孔的失效分析
- (2) PCB表面处理ENIG未浸润的失效分析
- (3) PCB 引线键合及钎焊电镀镍金表面处理的失效分析

6.7.4 主要参考文献

- (1) Fei-Jun Chen, Shi Yan, Zhen-Guo Yang*. Failure Analysis on Electrolytic Ni/Au Surface Finish of PCB Used for Wire Bonding and Soldering. *Soldering & Surface Mount Technology*, 2014, 26(4): 180–193.
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6.8 风电设备的失效分析

6.8.1 典型案例分析

- (1) 海上4 MW风电设备变压器超温燃烧的失效分析
- (2) 1.5MW风电设备齿轮箱轴承异常磨损的失效分析

6.8.2 主要参考文献

- (1) Yi-Min Zhu, Yi Gong, Zhen-Guo Yang*. Root cause analysis on over-temperature combustion of transformers in 4 MW offshore wind turbines. *Engineering Failure Analysis*, 2019, 96: 211-222.
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6.9 城市管网的失效分析

6.9.1 典型案例分析

- (1) 地铁附近埋地Dn1000管线异常泄漏的腐蚀失效分析
- (2) 冲刷腐蚀工况下不同管道的失效机理与预防方法

6.9.2 主要参考文献

- (1) Tong-Wei Ni, Tong-Tong Bi, Zhen-Guo Yang*. Corrosion failure analysis on abnormal leakage of buried Dn1000 gas pipeline near Subway Line. Engineering Failure Analysis, 2018, submitted
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第六章 思考题

1. 概述一下核电装置RCW热交换器传热钛管失效案例分析的主要步骤。你认为该案例分析中哪些方法应用得比较成功？
2. 在对超超临界1000MW火电机组进口循环水泵的失效分析过程中，该吸取什么样的经验教训？
3. 从PTA干燥器的失效案例分析中，简述一下在管理和维护上应注意什么？
4. 化工装置常有腐蚀与磨损的交互作用工况，试从管道失效分析中谈谈应如何选材以及用什么方法可减缓这类腐蚀的严重性？
5. 在冶炼设备的失效案例中，哪些因素可能会导致燃气轮机叶片发生过早的失效？
6. 通过对汽车踏板开展失效分析，你认为这类复合材料构件还可能发生哪些失效机制？其原因可能是什么？
7. 微电子器件都要进行表面处理，从芯片电镀高速钢带及其引线键合的失效分析中，电镀质量的改善一般需要控制哪些因素？
8. 印制电路板是层状复合材料，试从高密度互连PCB的失效分析中，概述可能会发生哪些失效机理？应该如何预防？